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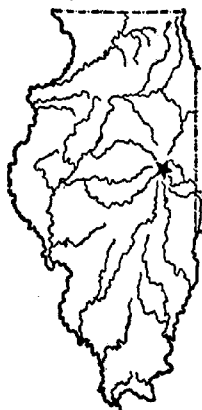
BULLETIN No. 200

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DIGESTION EXPERIMENTS WITH PIGS  
WITH SPECIAL REFERENCE  
TO THE INFLUENCE OF ONE FEED UPON ANOTHER, AND  
TO THE INDIVIDUALITY OF PIGS

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By H. S. GRINDLEY, W. J. CARMICHAEL, AND C. I. NEWLIN



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# DIGESTION EXPERIMENTS WITH PIGS

WITH SPECIAL REFERENCE

## TO THE INFLUENCE OF ONE FEED UPON ANOTHER, AND TO THE INDIVIDUALITY OF PIGS

By H. S. GRINDLEY, CHIEF IN ANIMAL NUTRITION,  
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### OBJECTS OF THE EXPERIMENTS

The objects of the experiments reported in this bulletin were as follows: (a) to determine the influence of one feed upon the digestibility of the nutrients of another feed; (b) to study the individuality of pigs as to the thoroughness with which they digest their feed; and (c) to determine the coefficients of apparent digestibility<sup>1</sup> of the nutrients of the following rations: (1) wheat flour middlings, (2) ground corn, (3) ground barley, (4) wheat flour middlings and ground corn in the ratio of 1 to 1, (5) ground barley and ground corn in the ratio of 1 to 1, and (6) tankage and ground corn in the ratio of 1 to 7.5. In order to secure experimental data that would answer the questions suggested by the above objects, ground corn, wheat flour middlings, and tankage were the feeds used in the first series of experiments; and ground corn, ground barley, and tankage were used in the second series of experiments.

### FIRST SERIES OF EXPERIMENTS, 1913-1914

#### PLAN

Four cross-bred Berkshire-Chester White barrows a little over seven months old, and all from the same litter, were selected for this work and put into specially constructed pens. These pens (Fig. 1) were large enough to allow the pigs to turn around conveniently, and were raised some three feet from the floor to enable an easy collection of the urine. They were provided with removable galvanized-iron feed troughs (Fig. 2) and with hinged doors, thru which the animals were

<sup>1</sup>Strictly speaking, the coefficients of the *real* digestibility of the nutrients of feeds cannot as yet be determined, for it is impossible to estimate accurately in the feces, either the metabolic products of intestinal action or the products resulting from tissue metabolism that are excreted thru the intestinal walls into the alimentary canal. Therefore, thruout this bulletin the coefficients of digestibility represent the coefficients of *apparent* digestibility; that is, merely the differences between the weights of the nutrients in the feeds and in the feces expressed in percent of the former.

driven to the weighing crate. The floor, consisting of a strong wire screen, fitted tightly over a galvanized-iron hopper leading to the urine pail (Fig. 3). No chemical analyses of the urines were made. The feces, collected in rubber-lined canvas bags held in place by means of a specially constructed harness (Fig. 4), were removed each day and placed in friction-top cans.

Corn and wheat flour middlings were chosen because they are two of the most common and practical feeds used for swine in the corn belt. No. 2 yellow corn was used. Digester tankage (meat meal) containing over 60 percent of protein was fed in two periods of the experiment. The barrows were fed twice daily, at 7 a. m. and 5 p. m. The different rations were given in amounts that the pigs would clean up readily, this quantity being determined during a period of several days' duration immediately preceding the experiments proper. Each of the rations was mixed with a definite amount of water (as much as the pigs would take) and fed as a moderately thin slop.

The first ration for which the coefficients of digestibility were determined consisted approximately of 2.17 pounds of middlings per 100 pounds live weight; the second, of 1.04 pounds of middlings and 1.04 pounds of ground corn per 100 pounds live weight; the third, of 2.06 pounds of ground corn per 100 pounds live weight; the fourth of 1.84 pounds of middlings per 100 pounds live weight; and the fifth, of 1.74 pounds of ground corn and 0.23 pounds of tankage per 100 pounds live weight. Each of these rations was fed for two ten-day test periods, during which time composite samples of the feeds and feces were taken for chemical analysis.

Each group of the two ten-day test periods was preceded by a preliminary period of twenty-five to thirty-two days' duration. During the first seven to ten days of each preliminary period, the change in the kinds of feed was made; during the remainder of the preliminary period, the pigs were fed the same ration in the same amounts per hundred pounds of live weight that they were to be fed during the two test periods immediately following. During the last ten days of each preliminary period, the pigs were in their pens, fully harnessed, in order that they might have sufficient time to become accustomed to the experimental conditions before any data were recorded.

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#### CHEMICAL COMPOSITION OF FEEDS AND FECES; AND WEIGHTS OF PIGS, FEEDS, WATER, FECES, AND URINE

The chemical composition of the feeds and fresh feces are given in Tables 1 and 3, respectively. The weights of the pigs, the feeds, the water, the feces, and the urine for each experimental period are given in Table 2.

From the data given in Table 2, it will be noted that the weights of the feces per pound of feed varied markedly depending upon the

character of the ration. The average weights of the fresh feces per pound of feed were as follows: In Periods 1 and 2, and 7 and 8, in which middlings alone were fed, 1.13 and 0.99 pounds, respectively; in Periods 3 and 4, in which middlings and ground corn in the ratio of 1 to 1 were fed, 0.74 pounds; in Periods 9 and 10, in which tankage and ground corn in the ratio of 1 to 7.5 were fed, 0.39 pounds; and in Periods 5 and 6, in which ground corn alone was fed, 0.355 pounds.

Examination of Table 3, giving the composition of the fresh feces, and of Table 4, showing the coefficients of digestibility of the nutrients of the rations, shows that the above differences in weights of the feces per pound of feed due to the character of the ration consumed, can be traced, in large part at least, to the variations in the water content of the feces and to the variations in the coefficients of digestibility of the dry substance of the rations. Thus, the average water content of the feces for the several periods was as follows: Periods 1 and 2, and 7 and 8, in which middlings alone were fed, 79.83 and 76.51 percent, respectively; Periods 3 and 4, in which middlings and ground corn in the ratio of 1 to 1 were fed, 75.15 percent; Periods 9 and 10, in which tankage and ground corn in the ratio of 1 to 7.5 were fed, 69.83; and Periods 5 and 6, in which ground corn alone was fed, 70.28 percent.

The average coefficients of digestibility of the dry substance of the rations for the several periods were as follows: Periods 1 and 2, and 7 and 8, in which middlings alone were fed, 74.7 and 74.2, respectively; Periods 3 and 4, in which middlings and ground corn in the ratio of 1 to 1 were fed, 79.1; Periods 9 and 10, in which tankage and ground corn in the ratio of 1 to 7.5 were fed, 86.8; and Periods 5 and 6, in which ground corn alone was fed, 87.9.

TABLE 1.—CHEMICAL COMPOSITION OF THE FEEDS  
(Results expressed in percent of the fresh substance)

Kind of feed	Used in periods	Dry sub- stance	Nitro- gen- free ex- tract	Crude fiber	Crude pro- tein	Ether ex- tract	Crude ash	Non- pro- tein nitro- gen	Total nitro- gen
Ground corn....	3, 4, 5, 6	86.38	71.74	1.95	8.45	2.95	1.29	0.177	1.352
Ground corn....	9, 10	88.47	71.63	2.31	9.30	3.95	1.28	0.156	1.489
Average.....	.....	87.42	71.68	2.13	8.87	3.45	1.28	0.166	1.420
Wheat flour middlings....	1, 2	89.64	54.98	5.92	18.33	5.85	4.58	0.615	2.932
Wheat flour middlings....	3, 4, 7, 8	89.95	54.98	6.01	18.06	6.05	4.75	0.631	2.890
Average.....	.....	89.79	54.98	5.97	18.19	5.95	4.66	0.623	2.911
Tankage.....	9, 10	92.06	3.96	3.10	62.58	7.56	14.84	3.382	10.013

TABLE 2.—WEIGHTS OF PIGS, FEEDS, WATER, FECES, AND URINE  
(Results expressed in pounds)

Pig	Live weight	Feeds consumed				Water	Total feces	Feces per lb. of feed	Total urine <sup>1</sup>
		Mid- dlings	Ground corn	Total	Per day per 100 lbs. live weight				
First Test Period. December 18 to 27, 1913. Ten days. Middlings									
113	181.8	39.60	.....	39.60	2.18	158.40	44.67	1.13	.....
213	181.5	39.60	.....	39.60	2.18	158.40	48.31	1.22	.....
313	149.4	33.00	.....	33.00	2.21	132.00	37.50	1.14	.....
413	149.3	33.00	.....	33.00	2.21	132.00	35.23	1.07	.....
Average	165.5	36.30	.....	36.30	2.20	145.20	41.43	1.14	.....
Second Test Period. December 28, 1913 to January 6, 1914. Ten days. Middlings									
113	186.5	39.60	.....	39.60	2.12	158.40	45.37	1.15	.....
213	186.7	39.60	.....	39.60	2.12	158.40	46.39	1.17	.....
313	153.1	33.00	.....	33.00	2.16	132.00	35.95	1.09	.....
413	154.5	33.00	.....	33.00	2.14	132.00	35.36	1.07	.....
Average	170.2	36.30	.....	36.30	2.14	145.20	40.77	1.12	.....
Third Test Period. January 24 to February 2, 1914. Ten days. Middlings and ground corn (1 to 1)									
113	207.0	22.00	22.00	44.00	2.13	176.00	31.99	0.73	120.04 <sup>2</sup>
213	207.6	22.00	22.00	44.00	2.12	176.00	32.33	0.73	136.38
313	174.3	18.00	18.00	36.00	2.07	144.00	25.72	0.71	113.05
413	172.4	18.00	18.00	36.00	2.09	144.00	26.18	0.73	114.32
Average	190.3	20.00	20.00	40.00	2.10	160.00	29.05	0.72	120.95
Fourth Test Period. February 3 to 12, 1914. Ten days. Middlings and ground corn (1 to 1)									
113	213.2	22.00	22.00	44.00	2.06	176.00	33.84	0.77	134.42
213	212.0	22.00	22.00	44.00	2.08	176.00	33.63	0.76	136.80
313	177.0	18.00	18.00	36.00	2.03	144.00	26.51	0.74	104.86 <sup>3</sup>
413	175.7	18.00	18.00	36.00	2.05	144.00	27.54	0.76	90.84 <sup>4</sup>
Average	194.5	20.00	20.00	40.00	2.06	160.00	30.38	0.76	116.73
Fifth Test Period. March 7 to 17, 1914. Ten days. Ground corn									
113	228.0	.....	48.00	48.00	2.11	180.90	17.12	0.36	153.95
213	231.4	.....	48.00	48.00	2.07	164.70	18.85	0.39	143.64
313	193.3	.....	40.00	40.00	2.07	157.10	13.62	0.34	136.69
413	192.5	.....	40.00	40.00	2.08	120.00	13.58	0.34	103.71
Average	211.3	.....	44.00	44.00	2.08	155.67	15.79	0.36	134.50

<sup>1</sup>Weight of urine for first and second periods not recorded.

<sup>2</sup>Weight for 9 days only.

<sup>3</sup>Weight for 8 days only.

TABLE 2.—*Concluded*

Pig	Live weight	Feeds consumed				Water	Total feces	Feces per lb. of feed	Total urine
		Mid- dlings	Ground corn	Total	Per day per 100 lbs. live weight				
Sixth Test Period. March 18 to 27, 1914. Ten days. Ground corn									
113	234.2	.....	48.00	48.00	2.05	160.40	16.80	0.35	137.19
213	236.0	.....	48.00	48.00	2.03	181.80	17.97	0.37	155.07
313	197.3	.....	40.00	40.00	2.03	160.00	13.07	0.33	140.35
413	196.8	.....	40.00	40.00	2.03	125.50	14.00	0.35	111.10
Average	216.1	.....	44.00	44.00	2.04	156.92	15.46	0.35	135.93
Seventh Test Period. April 26 to May 5, 1914. Ten days. Middlings									
113	283.0	52.00	.....	52.00	1.84	208.00	57.00	1.10	150.94
213	283.2	52.00	.....	52.00	1.84	208.00	52.66	1.01	155.93
313	248.3	46.00	.....	46.00	1.85	184.00	45.57	0.99	140.66
413	240.8	46.00	.....	46.00	1.91	184.00	46.89	1.02	142.76
Average	263.8	49.00	.....	49.00	1.86	196.00	50.53	1.03	147.57
Eighth Test Period. May 6 to 15, 1914. Ten days. Middlings									
113	292.3	52.00	.....	52.00	1.78	208.00	51.64	0.99	155.32
213	290.7	52.00	.....	52.00	1.79	208.00	50.14	0.96	155.81
313	255.3	46.00	.....	46.00	1.80	184.00	44.67	0.97	142.21
413	247.7	46.00	.....	46.00	1.86	184.00	40.94	0.89	143.65
Average	271.5	49.00	.....	49.00	1.81	196.00	46.85	0.95	149.25
Ninth Test Period. June 5 to 14, 1914. Ten days. Tankage and ground corn (1 to 7.5)									
113	332.0	8.00	60.00	68.00	2.05	210.50	24.57	0.36	100.62
213	332.7	8.00	60.00	68.00	2.04	201.00	29.72	0.44	102.91
313	292.4	6.60	50.00	56.60	1.94	191.20	21.10	0.37	110.28
413	283.4	6.60	50.00	56.60	2.00	176.60	23.59	0.42	113.20
Average	310.1	7.30	55.00	62.30	2.01	194.82	24.74	0.40	106.75
Tenth Test Period. June 15 to 24, 1914. Ten days. Tankage and ground corn (1 to 7.5)									
113	347.4	8.00	60.00	68.00	1.96	205.10	26.04	0.38	126.70
213	346.4	8.00	60.00	68.00	1.96	193.50	29.40	0.43	119.02
313	302.6	6.60	50.00	56.60	1.87	191.80	19.59	0.35	127.79
413	297.1	6.60	50.00	56.60	1.91	157.70	21.43	0.38	98.03
Average	323.4	7.30	55.00	62.30	1.93	187.02	24.11	0.38	117.88



TABLE 3.—CHEMICAL COMPOSITION OF THE FECES  
(Results expressed in percent of fresh substance)

Pig	Dry substance	Nitrogen-free extract	Crude fiber	Crude protein	Ether extract	Crude ash	Non-protein nitrogen	Total nitrogen	Nitrogen insoluble in acid pepsin
First Test Period. December 18 to 27, 1913. Ten days. Middlings									
113	19.64	8.05	4.12	3.47	0.93	3.02	0.161	0.555	0.265
213	19.34	7.99	3.87	3.39	1.07	3.03	0.157	0.542	0.213
313	18.88	7.84	3.97	3.14	0.88	3.06	0.158	0.502	0.210
413	21.08	8.89	4.14	3.79	1.06	3.20	0.163	0.607	0.198
Average	19.74	8.19	4.02	3.45	0.98	3.08	0.160	0.551	0.206
Second Test Period. December 28, 1913 to January 6, 1914. Ten days. Middlings									
113	19.34	8.35	4.02	3.19	0.66	3.13	0.189	0.510	0.205
213	19.78	8.61	4.07	3.20	0.88	3.03	0.172	0.511	0.194
313	21.07	9.46	4.63	2.94	0.76	3.27	0.140	0.471	0.208
413	22.23	10.39	3.64	3.83	1.11	3.26	0.140	0.590	0.187
Average	20.60	9.20	4.09	3.29	0.85	3.17	0.160	0.520	0.198
Third Test Period. January 24 to February 2, 1914. Ten days. Middlings and ground corn (1 to 1)									
113	25.38	12.62	4.48	3.97	1.34	2.97	0.129	0.635	0.228
213	25.39	12.62	4.27	4.24	1.31	2.95	0.129	0.678	0.201
313	24.28	11.77	4.96	3.42	0.80	3.34	0.098	0.546	0.293
413	24.71	11.62	4.82	4.55	0.73	3.01	0.130	0.727	0.260
Average	24.94	12.16	4.63	4.04	1.04	3.07	0.121	0.646	0.245
Fourth Test Period. February 3 to 12, 1914. Ten days. Middlings and ground corn (1 to 1)									
113	24.61	11.25	5.23	3.78	1.29	3.06	0.129	0.605	0.224
213	24.28	12.05	4.35	4.10	0.93	2.85	0.152	0.655	0.181
313	25.18	12.00	5.31	3.93	0.79	3.14	0.207	0.628	0.183
413	25.01	12.08	4.76	4.51	0.87	2.85	0.177	0.721	0.257
Average	24.77	11.85	4.91	4.08	0.97	2.97	0.166	0.652	0.211
Fifth Test Period. March 7 to 17, 1914. Ten days. Ground corn									
113	27.41	13.90	3.98	5.49	1.39	2.66	0.180	0.878	0.206
213	29.43	13.77	3.91	6.08	2.21	2.46	0.172	0.973	0.183
313	29.83	15.92	3.43	5.90	1.80	2.76	0.177	0.944	0.219
413	29.25	13.65	4.03	5.84	3.18	2.56	0.170	0.935	0.210
Average	28.98	14.31	3.84	5.83	2.39	2.61	0.175	0.932	0.204

TABLE 3.—*Concluded*

Pig	Dry sub- stance	Nitro- gen- free ex- tract	Crude fiber	Crude pro- tein	Ether ex- tract	Crude ash	Non- pro- tein nitro- gen	Total nitro- gen	Nitro- gen in- soluble in acid pepsin
Sixth Test Period. March 18 to 27, 1914. Ten Days. Ground corn									
113	29.71	16.08	3.67	5.53	1.49	2.94	0.257	0.884	0.216
213	31.52	15.33	4.15	6.58	2.78	2.67	0.223	1.053	0.188
313	29.41	14.49	3.41	6.12	2.51	2.87	0.238	0.979	0.234
413	31.21	16.03	3.88	6.06	2.46	2.79	0.239	0.969	0.290
Average	30.46	15.48	3.78	6.07	2.31	2.82	0.239	0.971	0.232
Seventh Test Period. April 26 to May 5, 1914. Ten days. Middlings									
113	21.90	10.13	4.63	3.41	0.60	3.14	0.204	0.545	0.158
213	23.79	11.66	4.40	3.76	0.68	3.29	0.241	0.602	0.174
313	22.73	11.03	4.60	3.08	0.73	3.30	0.166	0.492	0.194
413	24.58	11.63	5.00	3.85	0.83	3.27	0.199	0.617	0.209
Average	23.25	11.11	4.66	3.52	0.71	3.25	0.202	0.564	0.184
Eighth Test Period. May 6 to 15, 1914. Ten days. Middlings									
113	22.29	9.96	4.96	3.52	0.43	3.41	0.201	0.563	0.206
213	23.61	10.91	5.02	3.65	0.63	3.40	0.198	0.583	0.207
313	23.68	10.73	4.97	3.27	0.73	3.58	0.146	0.523	0.196
413	25.34	11.59	5.34	4.04	0.89	3.49	0.207	0.647	0.217
Average	23.73	10.80	5.07	3.62	0.67	3.47	0.188	0.579	0.206
Ninth Test Period. June 5 to 14, 1914. Ten days. Tankage and ground corn (1 to 7.5)									
113	31.33	13.12	3.34	9.46	1.61	3.80	0.340	1.514	0.408
213	28.51	11.51	3.25	9.59	1.23	2.93	0.388	1.535	0.484
313	29.78	11.52	2.98	10.40	0.90	3.99	0.351	1.664	0.771
413	30.92	13.08	3.19	9.73	2.09	2.82	0.303	1.557	0.493
Average	30.14	12.31	3.19	9.80	1.46	3.38	0.346	1.568	0.539
Tenth Test Period. June 15 to 24, 1914. Ten days. Tankage and ground corn (1 to 7.5)									
113	30.85	12.92	2.97	9.38	1.53	4.05	0.386	1.501	0.557
213	30.13	12.53	2.83	9.68	1.76	3.33	0.403	1.548	0.608
313	29.59	11.13	2.75	10.32	1.57	3.83	0.371	1.652	0.725
413	30.22	12.05	2.89	10.17	1.96	3.14	0.369	1.628	0.579
Average	30.20	12.16	2.86	9.89	1.70	3.59	0.382	1.582	0.617

## COEFFICIENTS OF DIGESTIBILITY OF THE NUTRIENTS OF THE RATIONS

The coefficients of the digestibility of the nutrients of the rations for the four pigs, as determined directly, for the ten periods of this series of experiments are given in Tables 4 and 5.

*Wheat Flour Middlings.*—It is evident from Table 4 that the coefficients of the digestibility of the nutrients of wheat flour middlings, when fed alone in Periods 1, 2, 7, and 8, varied somewhat

for the different animals during the same experimental period. It is also apparent that the coefficients varied considerably for the same animal in the different periods. This is especially true of the ether extract and the crude fiber. It is possible that the differences in the coefficients for Periods 1 and 2, on the one hand, and Periods 7 and 8, on the other hand, are due to the differences in the age and the weight of the animals. The pigs were about four and one-half months older, and weighed about 100 pounds more, during Periods 7 and 8 than during Periods 1 and 2.

The average coefficients of digestibility of the nutrients of wheat flour middlings when fed alone to each of the four pigs for the four ten-day periods (sixteen digestion trials) were as follows: dry substance, 74.4; nitrogen-free extract, 81.2; crude fiber, 21.0; crude protein, 80.0; and ether extract, 85.5.

*Ground Corn.*—The coefficients of digestibility of the nutrients of ground corn fed alone, in Periods 5 and 6, varied somewhat for the different pigs during the same period. The average coefficients of the dry substance, the nitrogen-free extract, and the crude protein of the ground corn agreed very closely for the two periods; the average values for the crude fiber and the ether extract did not vary much.

The average coefficients of digestibility of the nutrients of the ground corn when fed alone to each of the four pigs for the two ten-day periods (eight digestion trials) were as follows: dry substance, 87.9; nitrogen-free extract, 92.7; crude fiber, 30.8; crude protein, 75.0; and ether extract, 71.6. The average coefficients of the nutrients of ground corn when fed alone in four digestion trials previously reported from this station<sup>1</sup> were as follows: dry substance, 87.7; nitrogen-free extract, 93.6; crude fiber, 31.8; crude protein, 79.3; and ether extract, 71.3.

On comparing the average coefficients of the nutrients of the ration of ground corn fed alone with the corresponding averages for the ration of wheat flour middlings fed alone, it will be noted that the dry substance, the nitrogen-free extract, and the crude fiber of the ground corn were digested much more thoroly than the corresponding nutrients of the wheat flour middlings alone, while the crude protein and the ether extract of the ground corn were digested much less thoroly than those of the wheat flour middlings.

*Wheat Flour Middlings and Ground Corn (1 to 1).*—The coefficients of digestibility of the nutrients of the ration of wheat flour middlings and ground corn fed together in the ratio of 1 to 1, in Periods 3 and 4, varied somewhat for the different animals during the same period. The average coefficients of digestibility of all the nutrients of this ration, except the crude fiber, agreed very closely for the two periods.

<sup>1</sup>Dietrich and Grindley: Ill. Agr. Exp. Sta. Bul. 170.

The average coefficients of digestibility of the nutrients of the ration of wheat flour middlings and ground corn fed together in the ratio of 1 to 1 to each of the four pigs for the two ten-day periods (eight digestion trials) were as follows: dry substance, 79.1; nitrogen-free extract, 85.9; crude fiber, 12.1; crude protein, 77.3; and ether extract, 83.4.

On comparing the average coefficients of the nutrients of the ration of wheat flour middlings and ground corn fed together in the ratio of 1 to 1 with those of each of the rations of wheat flour middlings and of ground corn when fed alone, it will be noted that the coefficients of the nutrients for the ration of middlings and corn were in all cases, excepting that of the crude fiber, intermediate between those of the middlings fed alone and those of the corn fed alone.

*Tankage and Ground Corn (1 to 7.5).*—The coefficients of digestibility of the nutrients of the ration of tankage and ground corn fed together in the ratio of 1 to 7.5, in Periods 9 and 10, varied significantly for the different pigs during the same period. The average coefficients of all the nutrients of this ration, except the crude fiber, agreed closely for the two experimental periods.

The average coefficients of digestibility of the nutrients of the ration of tankage and ground corn fed together in the ratio of 1 to 7.5 to each of the four pigs for the two ten-day periods (eight digestion trials) were as follows: dry substance, 86.7; nitrogen-free extract, 92.5; crude fiber, 50.8; crude protein, 75.3; and ether extract, 85.8. The average coefficients of the nutrients of tankage and ground corn when fed together in ratios varying from 1:4 to 1:6 in six digestion trials previously reported from this station<sup>1</sup> were as follows: dry substance, 83.2; nitrogen-free extract, 92.4; crude fiber, 19.0; crude protein, 68.7; and ether extract, 76.4.

On comparing the coefficients of the nutrients of this ration with those of wheat flour middlings when fed alone, it will be noted that the dry substance, the nitrogen-free extract, and the crude fiber of the tankage and corn were digested much more thoroly than those of the wheat flour middlings alone, while the crude protein was digested decidedly less thoroly. The coefficients of digestibility of the ether extract were practically the same in the two rations.

A comparison of the coefficients of the nutrients of this ration with those of the ration of ground corn fed alone shows that the dry substance, the crude protein, and the nitrogen-free extract of the tankage and corn were digested practically to the same extent as those of the ground corn alone, while the ether extract and the crude fiber of the tankage and corn were digested much more thoroly than those of the ground corn alone.

<sup>1</sup>Dietrich and Grindley: Ill. Agr. Exp. Sta. Bul. 170.

TABLE 4.—COEFFICIENTS OF DIGESTIBILITY

Pig	Dry substance	Nitrogen-free extract	Crude fiber	Crude protein	Ether extract
First Test Period. December 18 to 27, 1913. Ten days. Middlings					
113	75.3	83.5	21.5	78.7	82.0
213	73.7	82.3	20.3	77.5	77.7
313	76.1	83.8	23.9	80.5	83.0
413	74.9	82.7	25.5	77.9	80.7
Average	75.0	83.1	22.8	78.7	80.9
Second Test Period. December 28, 1913 to January 6, 1914. Ten Days. Middlings					
113	75.3	82.6	22.3	80.1	87.2
213	74.2	81.7	19.6	79.6	82.5
313	74.4	81.3	14.9	82.5	85.8
413	73.4	79.7	34.1	77.6	79.6
Average	74.3	81.3	22.7	80.0	83.8
Third Test Period. January 24 to February 2, 1914. Ten days. Middlings and ground corn (1 to 1)					
113	79.1	85.5	19.2	78.2	78.3
213	78.8	85.4	22.1	76.5	78.6
313	80.3	86.7	12.0	81.6	87.4
413	79.6	86.7	13.0	75.1	88.2
Average	79.5	86.1	16.6	77.9	83.1
Fourth Test Period. February 3 to 12, 1914. Ten days. Middlings and ground corn (1 to 1)					
113	78.5	86.3	0.2	78.1	77.9
213	79.0	85.5	17.5	76.4	84.1
313	79.0	86.1	3.0	78.2	87.0
413	78.3	85.4	9.6	74.0	86.1
Average	78.7	85.8	7.6	76.7	83.8
Fifth Test Period. March 7 to 17, 1914. Ten days. Ground corn					
113	88.7	93.1	27.2	76.8	83.2
213	86.6	92.5	21.4	71.7	57.3
313	88.2	92.4	40.1	76.2	79.2
413	88.5	93.5	29.9	76.5	63.4
Average	88.0	92.9	29.7	75.3	70.8
Sixth Test Period. March 18 to 27, 1914. Ten days. Ground corn					
113	88.0	92.2	34.2	77.1	82.3
213	86.3	92.0	20.3	70.8	64.8
313	88.9	93.4	42.9	76.3	72.1
413	87.4	92.2	30.4	74.9	70.8
Average	87.7	92.5	32.0	74.8	72.5

TABLE 4.—*Concluded*

Pig	Dry substance	Nitrogen-free extract	Crude fiber	Crude protein	Ether extract
Seventh Test Period. April 26 to May 5, 1914. Ten days. Middlings					
113	73.3	79.8	15.5	79.5	89.0
213	73.2	78.5	26.0	79.1	88.5
313	74.9	80.1	18.3	83.3	87.8
413	72.1	78.4	15.3	78.4	85.8
Average	73.4	79.2	18.8	80.1	87.8
Eighth Test Period. May 6 to 15, 1914. Ten days. Middlings					
113	75.4	82.0	18.1	80.8	92.8
213	74.7	80.9	19.5	80.7	89.7
313	74.8	81.1	19.8	82.6	88.1
413	74.9	81.2	21.0	80.2	86.7
Average	75.0	81.3	19.6	81.1	89.3
Ninth Test Period. June 5 to 14, 1914. Ten days. Tankage and ground corn (1 to 7.5)					
113	87.3	92.6	49.9	78.1	86.7
213	86.0	92.1	41.1	73.1	87.7
313	87.5	93.3	53.9	75.0	92.3
413	85.5	91.5	44.7	73.9	80.1
Average	86.6	92.4	47.4	75.0	86.7
Tenth Test Period. June 15 to 24, 1914. Ten days. Tankage and ground corn (1 to 7.5)					
113	86.7	92.2	52.8	76.9	86.6
213	85.4	91.5	49.2	73.1	82.6
313	88.5	94.0	60.4	77.0	87.6
413	87.1	92.8	54.6	75.2	83.0
Average	86.9	92.6	54.3	75.6	85.0

#### THE INFLUENCE OF ONE FEED UPON THE DIGESTIBILITY OF THE NUTRIENTS OF ANOTHER FEED

The doubtful values obtained in digestion experiments in our previous work and in the work of others, by determining indirectly, or by calculation, the coefficients of the nutrients for one feed by subtracting the weights of the digestible nutrients of another feed from the corresponding values for the two feeds combined, led us to plan these experiments to determine more accurately, if possible, the influence of one feed upon the digestibility of the nutrients of another feed.

From the results of practical feeding experiments some authors have taken the view that when feeds are fed singly, they are not as completely digested as when fed in mixed rations, because rations composed of a single feed are not as efficient for producing growth and fattening as mixed feeds. For example, whenever milk is added to a

TABLE 5.—SUMMARY OF THE AVERAGE COEFFICIENTS OF DIGESTIBILITY OF THE RATIONS

	Period	Dry substance	Nitrogen-free extract	Crude fiber	Crude protein	Ether extract
Wheat flour middlings.....	1	75.0	83.1	22.8	78.7	80.9
Wheat flour middlings.....	2	74.3	81.3	22.7	80.0	83.8
Average.....	..	74.6	82.2	22.7	79.3	82.3
Wheat flour middlings.....	7	73.4	79.2	18.8	80.1	87.8
Wheat flour middlings.....	8	75.0	81.3	19.6	81.1	89.3
Average.....	..	74.2	80.2	19.2	80.6	88.5
Ground corn and middlings.....	3	79.5	86.1	16.6	77.9	83.1
Ground corn and middlings.....	4	78.7	85.8	7.6	76.7	83.8
Average.....	..	79.1	85.9	12.1	77.3	83.4
Ground corn.....	5	88.0	92.9	29.7	75.3	70.8
Ground corn.....	6	87.7	92.5	32.0	74.8	72.5
Average.....	..	87.8	92.7	30.8	75.0	71.6
Tankage and ground corn.....	9	86.6	92.4	47.4	75.0	86.7
Tankage and ground corn.....	10	86.9	92.8	54.3	75.6	85.0
Average.....	..	86.7	92.6	50.8	75.3	85.8

ration composed of a single grain, a larger amount of pork is produced than when the same amount of nutrients from the single grain is fed. It has therefore been assumed by some authors that in such cases the increased production is due to the fact that the milk increased the digestibility of the grains with which it was fed. However, it has recently been proved that there are other factors that favor increased production where the mixed rations are fed.

The data for the coefficients of digestibility of the nutrients of the wheat flour middlings, as determined directly when fed alone, and as calculated indirectly from the results of direct digestion experiments with the ration of middlings and ground corn and of the ground corn alone, are given in Table 6. It will be noted that the individual data and the average data for the four pigs show that the calculated values indirectly determined for the coefficients of digestibility of the dry substance and the nitrogen-free extract of the middlings are significantly lower than the corresponding coefficients of the nutrients of the middlings determined directly by the digestion experiments.

The results indicate that there is no significant difference between the coefficients for the protein as calculated indirectly and as determined directly. The results for the ether extract are very irregular, but the average results indicate that the calculated values for the coefficients of the ether extract for the middlings are probably significantly higher than those determined directly by actual experiments. It is quite apparent from the experimental data here presented that the calculated coefficients for the crude fiber are very irregular as compared with those determined directly.

TABLE 6.—COEFFICIENTS OF DIGESTIBILITY OF MIDLINGS, DIRECTLY AND INDIRECTLY DETERMINED

Pig	Dry substance	Nitrogen-free extract	Crude fiber	Crude protein	Ether extract
Middlings fed alone. First Test Period					
113	75.3	83.5	21.5	78.7	82.0
213	73.7	82.3	20.3	77.5	77.7
313	76.1	83.8	23.9	80.5	83.0
413	74.9	82.7	25.5	77.9	80.7
Average	75.0	83.1	22.8	78.7	80.8
Middlings calculated from middlings and corn ration. Third and Fifth Test Periods					
113	69.9	75.6	16.6	78.9	75.9
213	71.4	76.1	22.4	78.7	89.0
313	72.2	79.3	3.0	84.1	91.4
413	71.1	77.7	7.6	74.4	100.3
Average	71.2	77.2	12.4	79.0	89.2
Middlings fed alone. Second Test Period					
113	75.3	82.6	22.3	80.1	87.2
213	74.2	81.7	19.6	79.6	82.5
313	74.4	81.3	14.9	82.5	85.4
413	73.4	79.7	34.1	77.6	79.6
Average	74.3	81.3	22.7	79.9	83.7
Middlings calculated from middlings and corn ration. Fourth and Sixth Test Periods					
113	69.5	78.8	-10.7	78.5	75.9
213	71.9	76.9	16.7	79.0	93.6
313	69.5	76.5	-9.8	79.1	94.3
413	69.8	76.6	2.9	73.5	93.6
Average	70.2	77.2	-0.2	77.5	89.3

The data for the coefficients of digestibility of the nutrients of the ground corn as determined directly when fed alone, and as calculated indirectly from the direct experiments with the combined ration composed of middlings and ground corn and the wheat flour middlings alone, are given in Table 7. A study of these data leads in general to the same conclusions as to the variations and differences between the direct and indirect coefficients of the nutrients of the ground corn as were reached with regard to the direct and indirect values for wheat flour middlings. It should be said, however, that the calculated coefficients for the crude fiber and the ether extract of the corn are more irregular than the corresponding calculated coefficients for the wheat flour middlings.

The data for the coefficients of digestibility of the nutrients of the ration composed of one part of middlings and one part of ground



corn, as determined directly, and as calculated indirectly from the coefficients directly determined for middlings when fed alone and for ground corn when fed alone, are given in Table 8. It is apparent that the calculated coefficients for the ether extract of the ration are lower than those directly determined for the mixed ration. There is apparently no significant difference between the calculated coefficients and the directly determined coefficients for the protein of the mixed ration.

It is thus evident from the individual data, as well as from the average results given in Tables 6 to 8, inclusive, that the digestibility of the nutrients of a ration composed of equal parts of wheat flour middlings and ground corn are not what they would be if the coefficients of digestibility of the nutrients of each of the feeds when fed together had remained the same as they were in the individual feeds when fed alone. This difference between the directly and indirectly

TABLE 7.—COEFFICIENTS OF DIGESTIBILITY OF GROUND CORN, DIRECTLY AND INDIRECTLY DETERMINED

Pig	Dry substance	Nitrogen-free extract	Crude fiber	Crude protein	Ether extract
Ground corn fed alone. Fifth Test Period					
113	88.7	93.1	27.2	76.3	83.2
213	86.6	92.5	21.4	71.7	57.3
313	88.2	92.4	40.1	76.2	79.2
413	88.5	93.5	29.9	76.5	62.4
Average	88.0	92.9	29.6	75.3	70.8
Ground corn calculated from middlings and corn ration. First and Third Test Periods					
113	83.0	87.1	12.0	77.4	70.8
213	84.2	87.7	27.7	74.5	80.4
313	84.8	89.0	-25.3	83.9	96.5
413	84.5	89.7	-26.0	69.0	103.6
Average	84.1	88.4	-2.9	76.2	87.8
Ground corn fed alone. Sixth Test Period					
113	88.0	92.2	34.2	77.1	82.3
213	86.3	92.0	20.3	70.8	64.8
313	88.9	93.4	42.9	76.3	72.1
413	87.4	92.2	30.4	74.9	70.8
Average	87.6	92.4	31.9	74.8	72.5
Ground corn calculated from middlings and corn ration. Second and Fourth Test Periods					
113	81.9	89.2	-69.0	73.9	58.8
213	84.0	88.4	11.2	69.6	87.6
313	83.7	89.7	-34.2	69.6	89.0
413	83.4	89.8	-67.0	66.2	99.5
Average	83.3	89.3	-39.8	69.8	83.7

TABLE 8.—COEFFICIENTS OF DIGESTIBILITY OF A RATION OF MIDDINGS AND GROUND CORN (1 TO 1), DIRECTLY AND INDIRECTLY DETERMINED

Pig	Dry substance	Nitrogen-free extract	Crude fiber	Crude protein	Ether extract
Middlings and ground corn (1 to 1) fed together, direct determination. Third Test Period					
113	79.1	85.5	19.2	78.2	78.3
213	78.8	85.4	22.1	76.5	78.6
313	80.3	86.7	12.0	81.6	87.4
413	79.6	86.7	13.0	75.1	88.2
Average	79.5	86.1	16.6	77.9	88.1
Middlings and ground corn (1 to 1) calculated from the direct determinations of the middlings ration and the corn ration. First and Fifth Test Periods					
113	81.9	88.9	22.9	78.1	82.4
213	80.0	88.1	20.6	75.7	70.9
313	82.0	88.7	27.9	79.1	81.7
413	81.6	88.8	26.6	77.5	74.9
Average	81.4	88.6	24.5	77.6	77.5
Middlings and ground corn (1 to 1) calculated from the indirect determinations for the corn ration and the middlings ration (see second sections of Tables 6 and 7)					
113	76.3	82.1	15.5	78.4	74.2
213	77.7	82.7	23.7	77.4	86.1
313	78.4	84.8	-4.0	84.0	93.1
413	77.7	84.5	-0.7	72.7	101.4
Average	77.5	83.5	8.6	78.1	88.7
Middlings and ground corn (1 to 1) fed together, direct determination. Fourth Test Period					
113	78.5	86.3	0.2	78.1	77.9
213	79.0	85.5	17.6	76.4	84.1
313	79.0	86.1	3.0	78.2	87.0
413	78.3	85.4	9.6	74.0	86.1
Average	78.7	85.8	7.6	76.7	83.8
Middlings and ground corn (1 to 1) calculated from the direct determinations of the corn ration and the middlings ration. Second and Sixth Test Periods					
113	81.5	88.0	25.2	79.2	85.6
213	80.1	87.5	19.8	76.8	76.6
313	81.5	88.2	21.8	80.5	81.2
413	80.3	86.8	33.2	76.7	76.6
Average	80.8	87.6	25.0	78.3	80.0
Middlings and ground corn (1 to 1) calculated from the indirect determinations for the corn ration and the middlings ration (see fourth sections of Tables 6 and 7)					
113	75.6	84.7	-25.1	77.0	70.2
213	77.8	83.4	15.3	76.0	91.6
313	76.5	84.0	-15.8	75.9	92.5
413	76.5	84.1	-14.4	71.2	95.6
Average	76.6	84.0	-10.0	75.0	87.5

determined coefficients of the nutrients of the mixed ration may be due to one or the other of the following influences: First, it is possible that either the wheat flour middlings or the ground corn in the mixed ration influences directly the digestibility of the nutrients of the other feed. Second, it is possible, on the other hand, that there is a mutual influence of each feed upon the other, which results in decreasing the digestibility of the dry substance, the nitrogen-free extract, and the crude fiber; and in increasing the digestibility of the ether extract of the mixed ration.

#### INDIVIDUALITY OF PIGS AS TO THE THORONESS WITH WHICH THEY DIGEST THEIR FEED

From the preceding results it was possible to study the question of the individuality of pigs as to the thoroness with which they digest their feed. The influence of the individual peculiarities of experimental animals upon the thoroness of digestion of their feed is a matter of considerable interest. Very often when the same ration is fed to three or more animals of the same species, as many different coefficients of digestibility are obtained for the same nutrient as there are animals. The variations are usually not great, but they nearly always occur, and the question arises as to the part which the factor of individuality plays in producing these variations.

The data for the coefficients of digestibility of the crude protein obtained in forty digestion trials, of ten days each, in which four rations were fed to each of four pigs, are given in Table 9. Examination of the data shows that the individual coefficients for Pig 313 are significantly greater than the individual coefficients for Pig 213, in each of the ten experimental periods. A similar comparison of the coefficients of digestibility of protein for Pigs 313 and 413 shows a similar significant difference. Since conditions thruout the experiment were practically identical, the data lead clearly to the conclusion that, altho the pigs were litter mates and were fed together from birth, individuality was shown by a distinct and well-defined difference between the coefficients of digestibility of crude protein for Pig 313 and Pigs 213 and 413 thruout the ten experiments. A further study of the data in this table shows that for Pigs 113 and 213 and for Pigs 113 and 413 there was a considerable, tho less marked, difference in the coefficients of digestibility of crude protein which apparently can be assigned to the factor of individuality; but that there are practically no differences in the coefficients of digestibility of crude protein for Pigs 213 and 413 or for Pigs 113 and 313, that can be considered as due to the factor of individuality.

Examination of the data given in Table 9 for the coefficients of the dry matter, the nitrogen-free extract, and the ether extract shows in general the same individual differences as were found in the coeffi-

TABLE 9.—SUMMARY OF THE COEFFICIENTS OF DIGESTIBILITY OF THE NUTRIENTS SHOWING THE INDIVIDUALITY OF PIGS AS TO THE THORONNESS WITH WHICH THEY DIGESTED THEIR FEED

Period	Ration	Pig 313	Pig 113	Pig 413	Pig 213	Pig 313	Pig 113	Pig 413	Pig 213
		Crude protein				Ether extract			
1	Middlings (alone).....	80.5	78.7	77.9	77.5	83.0	82.0	80.7	77.7
2	Middlings (alone).....	82.5	80.1	77.6	79.6	85.8	87.2	79.6	82.5
7	Middlings (alone).....	83.3	79.5	78.4	79.1	87.8	89.0	85.8	88.5
8	Middlings (alone).....	82.6	80.8	80.2	80.7	88.1	92.8	86.7	89.7
3	Middlings and corn (1 to 1)...	81.6	78.2	75.1	76.5	87.4	78.3	88.2	78.6
4	Middlings and corn (1 to 1)...	78.2	78.1	74.0	76.4	87.0	77.9	86.1	84.1
5	Corn (alone).....	76.2	76.8	76.5	71.7	79.2	83.2	63.4	57.3
6	Corn (alone).....	76.3	77.1	74.9	70.8	72.1	82.3	70.8	64.8
9	Tankage and corn (1 to 7.5)....	75.0	78.1	73.9	73.1	92.3	86.7	80.1	87.7
10	Tankage and corn (1 to 7.5)....	77.0	76.9	75.2	73.1	87.6	86.6	83.0	82.6
	Average.....	79.3	78.4	76.4	75.8	85.0	84.6	80.4	79.3
		Dry substance				Nitrogen-free extract			
1	Middlings (alone).....	76.1	75.3	74.9	73.7	83.8	83.5	82.7	82.3
2	Middlings (alone).....	74.4	75.3	73.4	74.2	81.3	82.6	79.7	81.7
7	Middlings (alone).....	74.9	73.3	72.1	73.2	80.1	79.8	78.4	78.5
8	Middlings (alone).....	74.8	75.4	74.9	74.7	81.1	82.0	81.2	80.9
3	Middlings and corn (1 to 1)...	80.3	79.1	79.6	78.8	86.7	85.5	86.7	85.4
4	Middlings and corn (1 to 1)...	79.0	78.5	78.3	79.0	86.1	86.3	85.4	85.5
5	Corn (alone).....	88.2	88.7	88.5	86.6	92.4	93.1	93.5	92.5
6	Corn (alone).....	88.9	88.0	87.4	86.3	93.4	92.2	92.2	92.0
9	Tankage and corn (1 to 7.5)....	87.5	87.3	85.5	86.0	93.5	92.8	91.7	92.4
10	Tankage and corn (1 to 7.5)....	88.5	86.7	87.1	85.4	94.2	92.5	93.1	91.8
	Average.....	81.3	80.8	80.2	79.8	87.3	87.0	86.5	86.3

cients of digestibility of the crude protein for the four pigs. However, the individuality of these pigs with reference to their power of digesting dry matter, nitrogen-free extract, and ether extract is not so clearly evident as it was in the case of crude protein.

It is apparent, therefore, that in this series of experiments, all with the same animals, in which different rations were used in the different experiments, the coefficients as a whole showed constantly higher values for some animals than for other animals. Such consistent differences under such conditions must be attributed to the individuality of the different animals.

The total gains in weight of the four pigs during the ten experimental periods, each of ten days' duration, during which time each of the four animals received the same kinds of feed and the same quantities of feed per 100 pounds of live weight, were as follows: Pig 113, 79 pounds; Pig 213, 74 pounds; Pig 313, 57 pounds; and Pig 413, 65 pounds. The average live weights of the pigs during the ten experimental periods were as follows: Pig 113, 250.5 pounds; Pig 213, 250.8 pounds; Pig 313, 214.3 pounds; and Pig 413, 211.0 pounds. The weights of the total feeds consumed during this same time were as follows: Pig 113, 503.2 pounds; Pig 213, 503.2 pounds; Pig 313, 423.2 pounds; and Pig 413, 423.2 pounds. The weights of feed re-

quired to produce 100 pounds of gain during the ten experimental periods were as follows: Pig 113, 637 pounds; Pig 213, 680 pounds; Pig 313, 743 pounds; and Pig 413, 651 pounds. Comparing these gains in weight and the economy of the gains in weight with the average coefficients of digestibility of the nutrients of the feeds for each animal, it will be noted that there is no consistent correlation between the coefficients of digestibility and the gains, or the economy of gains, in weight. For example, Pig 113, which on the average digested all of the nutrients of the feeds more thoroly than did Pig 213 (which weighed the same and consumed an equal quantity of the same feeds as Pig 113) made a gain of 79 pounds and required 637 pounds of feed to produce 100 pounds of gain; while Pig 213 gained 74 pounds and required 680 pounds of feed to produce 100 pounds of gain. On the other hand, Pig 313, which on the average digested all of the nutrients of the feeds more thoroly than did Pig 413 (which weighed the same and consumed an equal quantity of the same feeds as Pig 313) made a gain of only 57 pounds and required 743 pounds of feed to produce 100 pounds of gain; while Pig 413 gained 65 pounds and required 651 pounds of feed to produce 100 pounds of gain.

This study clearly shows that different animals of the same species may show individuality as to the thoroness with which they digest the nutrients of their feeds. However, such differences in the coefficients of digestibility of the nutrients of the same feeds by different animals are probably too small to be considered of practical or economic importance.

## SECOND SERIES OF EXPERIMENTS, 1914-1915

### PLAN

Four cross-bred Duroc Jersey-Poland China barrows of the same age as the pigs used in the first series of experiments—namely, a few days over seven months, and all from the same litter—were selected for this second series of experiments. The pens, feed troughs, and digestion harness were the same as those used in the first experiments. In the second series ground barley (malting) was substituted for the wheat flour middlings used in the first series, but the ratio of feed to the live weight of the animals, the length of the transitional, the preliminary, and the test periods, and the general management and treatment of the animals were the same. The weather conditions during the two series of experiments were also similar.

The first ration for which the coefficients of digestibility were determined consisted of 2.08 pounds of ground barley (malting) per 100 pounds live weight; the second, of 1.05 pounds of ground barley and 1.05 pounds of ground corn (No. 2 yellow) per 100 pounds live weight; the third, of 2.12 pounds of ground corn per 100 pounds live weight; and the fourth, of 1.80 pounds of ground corn and 0.24 pounds of digester tankage per 100 pounds live weight. Each of these

rations was fed for two ten-day periods, during which time samples of the feeds and the feces were taken for chemical analysis.

CHEMICAL COMPOSITION OF FEEDS AND FECES; AND WEIGHTS OF PIGS,  
FEEDS, WATER, FECES, AND URINE

The chemical composition of the feeds and the fresh feces are given in Tables 10 and 12, respectively. The weights of the pigs, the feeds, the water, the feces, and the urine are presented in Table 11.

From the experimental data given in Table 11, it will be noted that the weights of the feces per pound of feed varied markedly depending upon the character of the ration. Thus the average weights of the fresh feces per pound of feed were as follows: in Periods 1 and 2, in which ground barley was fed, 0.96 pound; in Periods 3 and 4, in which ground barley and ground corn in the ratio of 1 to 1 were fed, 0.68 pound; in Periods 7 and 8, in which tankage and ground corn in the ratio of 1 to 7.5 were fed, 0.41 pound; and in Periods 5 and 6, in which ground corn was fed, 0.36 pound.

Examination of the data of Table 12, giving the composition of the fresh feces, and of Table 13, showing the coefficients of digestibility of the nutrients of the rations, shows that the differences mentioned above in the weights of the feces per pound of feed due to the character of the ration consumed can be traced, in large part at least, as in the first experiments, to the variations in the water content of the feces, and to the variations in the coefficients of digestibility of the dry substance of the rations. Thus, the average water content of the feces for the several periods was as follows: Periods 1 and 2, in which ground barley alone was fed, 72.20 percent; Periods 3 and 4, in which ground barley and ground corn in the ratio of 1 to 1 were fed, 74.91 percent; Periods 7 and 8, in which tankage and ground corn in the ratio of 1 to 7.5 were fed, 68.81 percent; and Periods 5 and 6, in which ground corn alone was fed, 67.74 percent. The average coefficients of

TABLE 10.—CHEMICAL COMPOSITION OF THE FEEDS  
(Results expressed in percent of the fresh substance)

Kind of feed	Used in periods	Dry sub- stance	Nitro- gen-free extract	Crude fiber	Crude protein	Ether extract	Crude ash	Total nitro- gen
Ground corn..	3, 4	86.32	69.85	3.73	9.51	3.73	1.17	1.522
Ground corn..	5, 6	83.94	68.17	2.06	9.15	3.37	1.18	1.464
Ground corn..	7, 8	86.22	71.37	2.29	9.31	2.06	1.19	1.489
Average....		85.49	69.80	2.69	9.32	3.05	1.18	1.492
Barley.....	1, 2	91.00	67.06	4.02	14.80	2.35	2.77	2.368
Barley.....	3, 4	91.07	70.04	4.96	11.29	2.14	2.65	1.806
Average....		91.03	68.55	4.49	13.04	2.24	2.71	2.087
Tankage.....	7, 8	88.65	12.51	5.33	53.53	8.15	15.49	9.364

TABLE 11.—WEIGHTS OF PIGS, FEEDS, WATER, FECES, AND URINE  
(Results expressed in pounds)

Pig	Live weight	Feeds consumed				Water	Total feces	Feces per lb. of feed	Total urine
		Barley	Ground corn	Total	Per day per 100 lbs. live weight				
First Test Period. November 27 to December 6, 1914. Ten days. Barley									
114	217.1	45.00	.....	45.00	2.07	143.40	39.01	0.87	100.76
214	182.4	38.40	.....	38.40	2.11	122.40	36.23	0.94	83.41
314	174.1	37.40	.....	37.40	2.15	119.00	35.33	0.94	80.12
414	158.9	33.00	.....	33.00	2.08	105.00	32.17	0.97	68.39
Average	183.1	38.45	.....	38.45	2.10	122.45	35.68	0.93	83.17
Second Test Period. December 7 to 16, 1914. Ten days. Barley									
114	222.9	45.00	.....	45.00	2.02	143.40	41.92	0.93	106.27
214	187.4	38.40	.....	38.40	2.05	122.40	37.07	0.97	86.00
314	177.9	37.40	.....	37.40	2.10	119.00	37.42	1.00	74.54
414	162.4	33.00	.....	33.00	2.03	105.00	34.99	1.06	67.97
Average	187.6	38.45	.....	38.45	2.05	122.45	37.85	0.99	83.69
Third Test Period. January 17 to 26, 1915. Ten days. Barley and ground corn (1 to 1)									
114	242.6	26.00	26.00	52.00	2.14	164.00	33.60	0.65	133.64
214	203.6	21.50	21.50	43.00	2.11	136.00	30.31	0.71	108.61
314	190.9	20.00	20.00	40.00	2.10	130.00	27.05	0.68	99.57
414	173.4	18.50	18.50	37.00	2.13	116.00	26.26	0.71	86.99
Average	202.6	21.50	21.50	43.00	2.12	136.50	29.30	0.69	107.05
Fourth Test Period. January 27 to February 5, 1915. Ten days. Barley and ground corn (1 to 1)									
114	247.6	26.00	26.00	52.00	2.10	164.00	31.96	0.62	132.65
214	207.4	21.50	21.50	43.00	2.07	136.00	28.77	0.67	108.45
314	195.6	20.00	20.00	40.00	2.04	130.00	26.22	0.66	100.16
414	177.1	18.50	18.50	37.00	2.09	116.00	26.94	0.73	87.68
Average	206.9	21.50	21.50	43.00	2.07	136.50	28.47	0.67	107.23
Fifth Test Period. March 6 to 15, 1915. Ten days. Ground corn									
114	280.9	.....	60.00	60.00	2.14	194.00	20.47	0.34	170.82
214	230.9	.....	48.60	48.60	2.10	158.00	17.38	0.36	139.98
314	218.1	.....	47.60	47.60	2.18	156.00	17.16	0.36	135.55
414	201.1	.....	43.80	43.80	2.18	142.00	17.45	0.40	118.51
Average	232.7	.....	50.00	50.00	2.15	162.50	18.11	0.36	141.21

TABLE 11.—*Concluded*

Pig	Live weight	Feeds consumed				Water	Total feces	Feces per lb. of feed	Total urine
		Tank-age	Ground corn	Total	Per day per 100 lbs. live weight				
Sixth Test Period. March 16 to 25, 1915. Ten days. Ground corn									
114	290.1	.....	60.00	60.00	2.07	194.00	21.35	0.36	172.29
214	239.1	.....	48.60	48.60	2.03	158.00	15.72	0.32	140.30
314	225.6	.....	47.60	47.60	2.11	156.00	16.69	0.35	132.43
414	207.6	.....	43.80	43.80	2.11	142.00	17.04	0.39	117.51
Average	240.6	.....	50.00	50.00	2.08	162.50	17.70	0.37	140.63
Seventh Test Period. April 22 to May 1, 1915. Ten days. Tankage and ground corn (1 to 7.5)									
114	352.6	8.54	64.06	72.60	2.06	220.00	30.84	0.42	173.22
214	286.9	6.87	51.53	58.40	2.04	182.00	21.43	0.37	139.52
314	275.6	6.70	50.30	57.00	2.07	178.00	22.97	0.40	130.58
414	256.1	6.35	47.65	54.00	2.11	172.00	21.40	0.40	133.61
Average	292.8	7.11	53.38	60.50	2.07	188.00	24.16	0.40	144.23
Eighth Test Period. May 2 to 11, 1915. Ten days. Tankage and ground corn (1 to 7.5)									
114	366.4	8.54	64.06	72.60	1.98	220.00	30.47	0.42	173.22
214	300.6	6.87	51.53	58.40	1.94	182.00	21.76	0.37	153.09
314	288.4	6.70	50.30	57.00	1.98	178.00	26.07	0.46	146.16
414	267.4	6.35	47.65	54.00	2.02	172.00	23.71	0.44	141.06
Average	305.7	7.11	53.38	60.50	1.98	188.00	25.50	0.42	153.38

digestibility of the dry substance of the rations for the several periods were as follows: Periods 1 and 2, in which ground barley alone was fed, 70.8; Periods 3 and 4, in which ground barley and ground corn in the ratio of 1 to 1 were fed, 80.9; Periods 7 and 8, in which tankage and ground corn in the ratio of 1 to 7.5 were fed, 85.3; and Periods 5 and 6, in which ground corn alone was fed, 86.2.

#### COEFFICIENTS OF DIGESTIBILITY OF THE NUTRIENTS OF THE RATIONS

The coefficients of digestibility of the nutrients of the rations for the four pigs, as determined directly, for the eight experimental periods of this series of experiments are given in Tables 13 and 14.

*Ground Barley.*—It is evident from Table 13 that the coefficients of digestibility of the nutrients for ground barley, when fed alone in Periods 1 and 2, varied for the different animals during the same experimental period. This is especially true of the coefficients for the crude fiber and the ether extract. It is also evident that the coefficients varied considerably for the same animal in different periods.



TABLE 12.—CHEMICAL COMPOSITION OF THE FECES  
(Results expressed in percent of fresh substance)

Pig	Dry substance	Nitrogen-free extract	Crude fiber	Crude protein	Ether extract	Crude ash	Total nitrogen
First Test Period. November 27 to December 6, 1914. Ten days. Barley							
114	27.86	14.03	3.67	6.77	0.95	2.45	1.083
214	27.86	13.43	3.66	6.69	1.82	2.26	1.070
314	29.13	13.94	3.59	7.58	1.79	2.24	1.213
414	26.81	11.79	3.88	7.13	1.83	2.18	1.141
Average	27.92	13.30	3.70	7.04	1.60	2.28	1.127
Second Test Period. December 7 to 16, 1914. Ten days. Barley							
114	25.25	10.94	3.88	7.08	0.89	2.46	1.132
214	28.30	13.69	3.85	6.63	1.90	2.24	1.060
314	29.34	14.01	3.65	7.66	1.81	2.21	1.222
414	27.82	13.49	3.08	7.14	1.99	2.12	1.143
Average	27.68	13.03	3.62	7.13	1.65	2.26	1.139
Third Test Period. January 17 to 26, 1915. Ten days. Barley and ground corn (1 to 1)							
114	24.97	11.97	4.41	4.82	0.88	2.45	0.771
214	24.16	11.52	4.48	4.85	0.99	2.31	0.776
314	24.95	10.86	5.12	5.15	1.47	2.35	0.824
414	23.15	10.21	4.34	5.29	1.13	2.18	0.846
Average	24.30	11.14	4.59	5.03	1.12	2.32	0.804
Fourth Test Period. January 27 to February 5, 1915. Ten days. Barley and ground corn (1 to 1)							
114	25.80	11.93	4.67	5.10	1.66	2.44	0.816
214	25.86	12.34	4.31	5.37	1.22	2.61	0.859
314	27.02	12.68	4.25	5.47	2.25	2.37	0.875
414	24.80	11.18	4.41	5.22	1.79	2.19	0.835
Average	25.87	12.03	4.41	5.29	1.73	2.40	0.846
Fifth Test Period. March 6 to 15, 1915. Ten days. Ground corn							
114	31.59	16.26	3.62	6.77	2.15	2.79	1.083
214	31.94	16.76	3.41	6.49	2.62	2.66	1.012
314	33.27	16.65	3.52	6.86	3.71	2.56	1.098
414	31.10	15.35	3.49	6.23	3.52	2.52	0.997
Average	31.98	16.26	3.51	6.59	3.00	2.63	1.048
Sixth Test Period. March 16 to 25, 1915. Ten days. Ground corn							
114	32.64	16.03	3.58	6.99	3.33	2.72	1.118
214	32.04	16.90	3.50	6.38	2.54	2.72	1.020
314	33.66	16.26	3.52	7.01	4.12	2.75	1.121
414	31.80	15.32	3.44	6.31	4.16	2.56	1.010
Average	32.54	16.13	3.51	6.67	3.54	2.69	1.067

TABLE 12.—*Concluded*

Pig	Dry substance	Nitrogen-free extract	Crude fiber	Crude protein	Ether extract	Crude ash	Total nitrogen
Seventh Test Period. April 22 to May 1, 1915. Ten days. Tankage and ground corn (1 to 7.5)							
114	32.39	13.24	3.20	9.78	1.73	4.42	1.565
214	30.28	12.17	2.93	9.80	1.81	3.58	1.568
314	31.67	13.33	3.24	9.23	2.13	3.74	1.476
414	32.85	14.26	3.27	9.76	1.45	4.11	1.561
Average	31.80	13.25	3.16	9.64	1.78	3.96	1.543
Eighth Test Period. May 2 to 11, 1915. Ten days. Tankage and ground corn (1 to 7.5)							
114	27.90	10.03	3.10	9.28	1.19	4.31	1.484
214	29.87	12.14	2.85	9.68	1.19	4.02	1.548
314	32.14	14.18	3.15	9.12	1.78	3.93	1.459
414	32.40	14.09	3.30	9.27	1.82	3.89	1.483
Average	30.58	12.61	3.10	9.34	1.50	4.04	1.494

The average coefficients of digestibility of the nutrients of ground barley when fed alone to the four pigs for the two ten-day periods (eight digestion trials) were as follows: dry substance, 70.8; nitrogen-free extract, 81.2; crude fiber, 14.1; crude protein, 54.0; and ether extract, 33.0. Ground barley was the least digestible of any of the rations used in this experiment. The coefficients of digestibility of the crude protein, the ether extract, and the crude fiber were very low.

*Ground Corn.*—The coefficients of digestibility of the nutrients of ground corn fed alone in Periods 5 and 6 varied somewhat for the different pigs during the same period. The average coefficients of digestibility of all the nutrients, except those of the ether extract, agreed very closely for the two periods.

The average coefficients of digestibility of the nutrients of the ground corn when fed alone to each of the four pigs for the two ten-day periods (eight digestion trials) were as follows: dry substance, 86.2; nitrogen-free extract, 91.5; crude fiber, 38.8; crude protein, 74.0; and ether extract, 64.9. These results for the dry substance, the crude protein, and the nitrogen-free extract agree closely with the corresponding average results obtained in the eight digestion experiments with corn reported in the first series of experiments.

On comparing the average coefficients of the nutrients of the ration of ground corn fed alone with the corresponding averages for the ration of ground barley fed alone, it will be noted that all of the nutrients of the ground corn were digested much more thoroly than those of the ground barley alone.

*Ground Barley and Ground Corn (1 to 1).*—The coefficients of digestibility of the nutrients of the ration of ground barley and ground

TABLE 13.—COEFFICIENTS OF DIGESTIBILITY

Pig	Dry substance	Nitrogen-free extract	Crude fiber	Crude protein	Ether extract
First Test Period. November 27 to December 6, 1914. Ten Days. Barley					
114	73.5	81.9	20.9	60.4	64.9
214	71.9	81.1	14.0	57.4	27.2
314	69.8	80.4	15.5	51.6	28.2
414	71.3	82.9	5.9 <sup>1</sup>	53.0	24.1
Average	71.6	81.6	16.8	55.6	36.1
Second Test Period. December 7 to 16, 1914. Ten days. Barley					
114	74.2	84.8	10.1	55.5	64.6
214	70.0	80.3	7.5	56.8	22.1
314	67.7	79.1	9.2	48.2	22.8
414	67.6	78.7	18.7	48.8	10.2
Average	69.9	80.7	11.4	52.3	29.9
Third Test Period. January 17 to 26, 1915. Ten days. Barley and ground corn (1 to 1)					
114	82.1	88.9	18.8	70.1	80.6
214	80.8	88.4	10.0	67.1	76.2
314	81.0	89.5	1.4 <sup>1</sup>	66.5	66.2
414	81.0	89.6	12.3	63.9	72.7
Average	81.2	89.1	13.7	66.9	73.9
Fourth Test Period. January 27 to February 5, 1915. Ten days. Barley and ground corn (1 to 1)					
114	82.1	89.5	18.2	69.9	65.3
214	80.5	88.2	17.8	65.5	72.1
314	80.0	88.1	20.6	65.5	49.8
414	79.6	88.4	8.5	63.5	59.5
Average	80.6	88.6	16.3	66.1	61.7
Fifth Test Period. March 6 to 15, 1915. Ten days. Ground corn					
114	87.2	91.9	40.1	74.8	78.3
214	86.4	91.2	40.9	74.6	72.3
314	85.7	91.2	38.4	73.0	60.3
414	85.2	91.0	32.6	72.9	58.4
Average	86.1	91.3	38.0	73.8	67.3
Sixth Test Period. March 16 to 25, 1915. Ten days. Ground corn					
114	86.2	91.6	38.2	72.8	64.9
214	87.7	92.0	45.0	77.5	75.6
314	85.4	91.6	40.0	73.2	57.2
414	85.3	91.3	35.0	73.2	52.0
Average	86.2	91.6	39.6	74.2	62.4

<sup>1</sup>Not included in the average.

TABLE 13.—*Concluded*

Pig	Dry substance	Nitrogen-free extract	Crude fiber	Crude protein	Ether extract
Seventh Test Period. April 22 to May 1, 1915. Ten days. Tankage and ground corn (1 to 7.5)					
114	84.1	91.3	48.6	72.5	73.5
214	87.2	93.1	59.4	76.2	76.2
314	85.2	91.7	50.7	75.4	69.2
414	85.2	91.2	51.1	74.4	79.3
Average	85.4	91.8	52.5	74.6	74.6
Eighth Test Period. May 2 to 11, 1915. Ten days. Tankage and ground corn (1 to 7.5)					
114	86.5	93.5	50.9	74.2	82.0
214	87.1	93.0	60.0	76.1	84.0
314	83.0	89.9	45.7	72.4	70.7
414	83.6	90.4	45.3	73.0	71.2
Average	85.1	91.7	50.5	73.9	77.0

TABLE 14.—SUMMARY OF THE AVERAGE COEFFICIENTS OF DIGESTIBILITY OF THE RATIONS

	Period	Dry substance	Nitrogen-free extract	Crude fiber	Crude protein	Ether extract
Ground barley.....	1	71.6	81.6	16.8	55.6	36.1
Ground barley.....	2	69.9	80.7	11.4	52.3	29.9
Average.....		70.8	81.2	14.1	54.0	33.0
Ground barley and ground corn.....	3	81.2	89.1	13.7	66.9	73.9
Ground barley and ground corn.....	4	80.6	88.6	16.3	66.1	61.7
Average.....		80.9	88.9	15.0	66.5	67.8
Ground corn.....	5	86.1	91.3	38.0	73.8	67.3
Ground corn.....	6	86.2	91.6	39.6	74.2	62.4
Average.....		86.2	91.5	38.8	74.0	64.9
Tankage and ground corn.....	7	85.4	91.8	52.5	74.6	74.6
Tankage and ground corn.....	8	85.1	91.7	50.5	73.9	77.0
Average.....		85.3	91.8	51.5	74.3	75.8

corn fed together in the ratio of 1 to 1 in Periods 3 and 4 varied for the different animals during the same period. This is especially true of the coefficients for the crude fiber, the ether extract, and the crude protein. The average coefficients of digestibility of the nutrients of this ration except the ether extract and the crude fiber agreed very closely for the two periods.

The average coefficients of digestibility of the nutrients of the ration of ground barley and ground corn fed together in the ratio of 1 to 1 to each of the four pigs for the two ten-day periods (eight diges-

tion trials) were as follows: dry substance, 80.9; nitrogen-free extract, 88.9; crude fiber, 15.0; crude protein, 66.5; and ether extract, 67.8. On comparing the average coefficients of the nutrients of the ration of ground barley and ground corn fed together in the ratio of 1 to 1 with those of the rations of ground barley and of ground corn when fed alone, it will be noted that the coefficients of the nutrients for the ration of barley and corn were in all cases, excepting those of the ether extract, intermediate between those of the barley fed alone and those of the corn fed alone.

*Tankage and Ground Corn (1 to 7.5).*—The coefficients of digestibility of the nutrients of this ration varied significantly for the different pigs during the same period. The average coefficients of all the nutrients of this ration agreed closely for the two experimental periods.

The average coefficients of digestibility of the nutrients of the ration of tankage and ground corn fed together in the ratio of 1 to 7.5 to each of the four pigs for the two ten-day periods (eight digestion trials) were as follows: dry substance, 85.3; nitrogen-free extract, 91.8; crude fiber, 51.5; crude protein, 74.3; and ether extract, 75.8. These results agree quite closely with the corresponding average results obtained in the eight digestion experiments with the same ration reported above in the first series of experiments.

On comparing the average coefficients of the nutrients of this ration with those of the ration of ground barley when fed alone, it will be noted that all of the nutrients of the tankage and ground corn were digested much more thoroly than those of the barley.

A comparison of the average coefficients of the nutrients of the ration of tankage and ground corn fed together with the ration of corn fed alone shows that the dry substance, the crude protein, and the nitrogen-free extract of the tankage and corn were digested to practically the same extent as those of the ground corn alone, while the ether extract and the crude fiber of the tankage and corn were digested much more thoroly than those of the ground corn alone. These findings are in accord with those obtained in the first series of experiments.

#### THE INFLUENCE OF ONE FEED UPON THE DIGESTIBILITY OF THE NUTRIENTS OF ANOTHER FEED

The data for the coefficients of digestibility of the nutrients of barley, as determined directly when fed alone, and as calculated indirectly from the results of direct digestion experiments with the combined ration composed of barley and ground corn and the ground corn alone, are given in Table 15. It will be noted that the individual data and the average data for the four pigs show that the calculated values indirectly determined for the coefficients of digestibility of the dry substance, the nitrogen-free extract, the crude protein, and the ether

TABLE 15.—COEFFICIENTS OF DIGESTIBILITY OF GROUND BARLEY, DIRECTLY AND INDIRECTLY DETERMINED

Pig	Dry substance	Nitrogen-free extract	Crude fiber	Crude protein	Ether extract
Ground barley fed alone. First Test Period					
114	73.5	81.9	20.9	60.4	64.9
214	71.9	81.1	14.0	57.4	27.2
314	69.8	80.4	15.5	51.6	28.2
414	71.3	82.9	5.9	53.0	24.1
Average	71.6	81.6	16.8	55.6	36.1
Ground barley calculated from the barley and corn ration. Third and Fifth Periods					
114	77.3	86.0	10.0	66.1	84.5
214	75.5	85.6	-2.9	60.8	83.0
314	76.5	87.8	-13.9	61.0	76.4
414	77.9	88.3	3.9	56.3	76.0
Average	76.8	86.9	-0.7	61.1	80.0
Ground barley fed alone. Second Test Period					
114	74.2	84.8	10.1	55.5	64.6
214	70.0	80.3	7.5	56.8	22.1
314	67.7	79.1	9.2	48.2	22.8
414	67.6	78.7	18.7	48.8	10.2
Average	69.9	80.7	11.4	52.3	29.9
Ground barley calculated from corn and barley ration. Fourth and Sixth Test Periods					
114	78.3	87.4	9.9	67.4	66.0
214	73.7	84.4	6.5	55.3	66.1
314	74.9	84.6	12.6	59.1	37.0
414	74.3	85.4	-2.6	55.3	61.8
Average	75.3	85.5	6.6	59.3	57.7

extract of the barley are considerably higher than the corresponding coefficients of the barley determined directly by the digestion experiments.

While the calculated results for the crude fiber are irregular, they nevertheless indicate that the calculated coefficients indirectly determined for this nutrient of the barley are, on the whole, somewhat lower than the corresponding coefficients of the barley determined directly.

The data for the coefficients of digestibility of the nutrients of the ground corn, as determined directly when fed alone, and as calculated indirectly from the direct experiments with the ration composed of barley and ground corn and the barley alone, are given in Table 16. A study of these data leads, in general, to the same conclusions as to the variations and differences between the direct and indirect coefficients of the nutrients of ground corn as were found in the case of the direct and indirect coefficients for barley.

The data for the coefficients of digestibility of the nutrients of the ration composed of one part of ground barley and one part of ground corn, as determined directly and as calculated indirectly, first, from the direct determinations for the barley and the corn rations, and second, from the indirect determinations for the barley and the corn rations are given in Table 17. It is apparent that the coefficients for the dry substance, the nitrogen-free extract, the crude protein, and the ether extract of the ration calculated from the coefficients for the ground barley and the ground corn, each determined directly, are considerably lower, while those for the crude fiber are considerably higher, than the corresponding coefficients directly determined for the mixed ration. These findings seem to prove that the dry substance,

TABLE 16.—COEFFICIENTS OF DIGESTIBILITY OF GROUND CORN, DIRECTLY AND INDIRECTLY DETERMINED

Pig	Dry substance	Nitrogen-free extract	Crude fiber	Crude protein	Ether extract
Ground corn fed alone. Fifth Test Period					
114	87.2	91.9	40.1	74.8	78.3
214	86.4	91.2	40.9	74.6	72.3
314	85.7	91.2	38.4	73.0	60.3
414	85.2	91.0	32.6	72.9	58.4
Average	86.1	91.3	38.0	73.8	67.3
Ground corn calculated from the barley and corn ration. First and Third Test Periods					
114	91.2	96.0	13.9	81.6	89.5
214	90.2	95.7	0.2	78.7	58.2
314	92.8	98.6	-32.5	84.2	88.0
414	92.2	96.4	30.5	76.9	56.4
Average	91.6	96.7	3.0	80.4	73.0
Ground corn fed alone. Sixth Test Period					
114	86.2	91.6	38.2	72.8	64.9
214	87.7	92.0	45.0	77.5	75.6
314	85.4	91.6	40.0	73.2	57.2
414	85.3	91.3	35.0	73.2	52.0
Average	86.2	91.6	39.6	74.2	62.4
Ground corn calculated from the barley and corn ration. Second and Fourth Test Periods					
114	90.5	94.3	37.7	86.9	65.7
214	91.6	96.1	42.5	75.7	44.7
314	93.0	97.2	48.3	86.1	65.4
414	92.4	98.0	-16.2	80.9	81.6
Average	91.9	96.4	28.1	82.4	64.4

TABLE 17.—COEFFICIENTS OF DIGESTIBILITY OF A RATION OF GROUND BARLEY AND GROUND CORN (1 TO 1), DIRECTLY AND INDIRECTLY DETERMINED

Pig	Dry substance	Nitrogen-free extract	Crude fiber	Crude protein	Ether extract
Ground barley and ground corn (1 to 1) fed together, direct determination. Third Test Period					
114	82.1	88.9	18.8	70.1	80.6
214	80.8	88.4	10.0	67.1	76.2
314	81.0	89.5	1.4	66.5	66.2
414	81.0	89.6	12.3	63.9	72.7
Average	81.2	89.1	13.7	66.9	73.9
Ground barley and ground corn (1 to 1) calculated from the direct determinations of the barley ration and the corn ration. First and Fifth Test Periods					
114	80.2	86.9	26.5	67.0	73.4
214	79.0	86.1	21.9	65.3	55.9
314	77.5	85.8	22.2	61.4	48.6
414	78.1	86.9	13.7	62.1	45.9
Average	78.7	86.4	21.1	64.0	56.0
Ground barley and ground corn (1 to 1) calculated from the indirect determinations for the barley ration and the corn ration (see second sections of Tables 15 and 16)					
114	87.1	91.0	11.1	73.2	87.7
214	82.7	90.6	-2.0	69.0	91.0
314	84.4	93.2	-19.3	71.6	83.8
414	84.9	92.3	11.0	65.7	98.7
Average	84.0	91.8	0.2	69.9	90.3
Ground barley and ground corn (1 to 1) fed together, direct determination. Fourth Test Period					
114	82.1	89.5	18.2	69.9	65.3
214	80.5	88.2	17.8	65.5	72.1
314	80.0	88.1	20.6	65.5	49.8
414	79.6	88.4	8.5	63.5	59.5
Average	80.6	88.6	16.3	66.1	61.7
Ground barley and ground corn (1 to 1) calculated from the direct determinations of the barley ration and the corn ration. Second and Sixth Test Periods					
114	80.0	88.2	18.3	63.4	64.8
214	78.6	86.1	18.5	66.3	56.1
314	76.3	85.3	18.2	59.6	44.7
414	76.2	85.0	23.5	60.0	42.1
Average	77.8	86.2	19.6	62.3	51.9
Ground barley and ground corn (1 to 1) calculated from the indirect determination of the barley ration and the corn ration (see fourth sections of Tables 15 and 16)					
114	84.2	90.8	18.0	76.3	65.8
214	82.4	90.2	17.0	64.7	87.1
314	83.8	90.9	23.1	71.4	55.0
414	83.1	91.1	-6.5	67.0	76.6
Average	83.4	90.8	12.9	69.9	71.1



the nitrogen-free extract, the crude protein, and the ether extract of the two feeds when fed together are more digestible than they are when fed alone, while the crude fiber is less digestible. On the other hand, it is evident from the data given in Table 17 that the coefficients for the dry substance, the nitrogen-free extract, the crude protein, and the ether extract of the ration calculated from the coefficients determined indirectly for the barley and the ground corn rations are considerably higher, while those of the crude fiber are considerably lower, than the corresponding coefficients directly determined for the mixed ration.

It should be noted in this connection that the coefficients for the dry substance and the nitrogen-free extract for the wheat flour middlings and the ground corn ration, calculated from the direct determinations of the middlings and the ground corn fed singly (see page 69), were *considerably higher* than those directly determined from the mixed ration. However, the coefficients for the dry substance and the nitrogen-free extract for the barley and ground corn ration, calculated from the direct determinations of the barley and ground corn fed singly (see page 83), were *considerably lower* than those directly determined from the mixed ration. Further, the coefficients for the protein of the wheat flour middlings and the ground corn ration, calculated from the direct determinations of the middlings and the ground corn fed singly, were *not much different* from those directly determined for the mixed ration. However the coefficients for the protein of the barley and ground corn ration, calculated from the direct determinations of the barley and corn fed singly, were *considerably lower* than those directly determined from the mixed ration.

It is therefore evident that, in some cases, one feed does not influence the digestibility of the individual nutrients of another feed and, in other cases, it does influence the digestibility of the individual nutrients of the other feed in one of the two following ways: first, the nutrients of the feeds when fed as mixed feeds are more digestible than they are when each feed is used alone; or, second, the nutrients of feeds when fed as mixed feeds are less digestible than they are when each feed is used alone. With the limited data at present available relating to this subject, it is impossible to explain logically the above mentioned differences shown by different combinations of feeds upon the digestibility of their nutrients as compared with the digestibility of the nutrients of the individual feeds when fed alone. This subject is being further studied at this station.

The results of these researches on the influence of one feed upon the digestibility of another feed demonstrate clearly, first, that the coefficients of digestibility of feeds calculated indirectly by subtracting the weights of the digestible nutrients of one feed as directly determined in other periods from the corresponding values for two feeds

combined may be, and probably often are, decidedly inaccurate; and second, that the weights of the digestible nutrients of a mixed ration calculated by the use of the coefficients of digestibility of the nutrients obtained directly for the individual feeds when fed alone may be decidedly inaccurate.

It therefore seems evident from these considerations that, in order to obtain accurate results for the coefficients of digestibility of mixed rations, digestion experiments should be made directly upon the mixed rations as fed. In other words, in the future, coefficients of digestibility of the nutrients for *mixed* rations should be obtained and reported, rather than merely those for the *individual* feeds composing the rations.

#### INDIVIDUALITY OF PIGS AS TO THE THORONESS WITH WHICH THEY DIGEST THEIR FEED

The data for the coefficients of digestibility of the crude protein obtained in thirty-two digestion trials of ten days each, in which four rations were fed to each of four pigs, are given in Table 18. Examination of the figures shows that the individual coefficients for Pig 214 are significantly greater than the individual coefficients for Pig 414, in each of the eight experiments. A similar comparison of the coefficients of digestibility of protein for Pigs 214 and 314 demonstrates a similar significant difference. Since conditions thruout the experiment were practically identical, the pigs also being litter mates and having been fed together from birth, the data lead clearly to the conclusion that the distinct and well-defined differences between the coefficients of digestibility of crude protein for Pig 214 and Pigs 314 and 414 thruout the eight experiments must have been due to individuality. A further study of the data of this table shows that there is a considerable difference between the coefficients of digestibility of crude protein for Pigs 114 and 314 and for Pigs 114 and 414 that apparently can be assigned to the factor of individuality. However, there are practically no differences in the coefficients of digestibility of crude protein for Pigs 114 and 214, or for Pigs 314 and 414, that can be assigned to the factor of individuality.

Examination of the results presented in Table 18 for the coefficients of digestibility of the ether extract of the four rations shows that there were marked and well-defined differences due apparently to the individuality of the pigs.

Inspection of the data given in Table 18 for the coefficients of the dry matter and the nitrogen-free extract, shows that there was a tendency toward individual differences especially in the average results. However, the individuality of these pigs with reference to their power of digesting dry matter and nitrogen-free extract is not so clearly evident as it is in the case of crude protein and ether extract.

TABLE 18.—SUMMARY OF THE COEFFICIENTS OF DIGESTIBILITY OF THE NUTRIENTS SHOWING THE INDIVIDUALITY OF PIGS AS TO THE THORONESS WITH WHICH THEY DIGESTED THEIR FEED

Period	Ration	Pig 214	Pig 114	Pig 314	Pig 414	Pig 214	Pig 114	Pig 314	Pig 414
		Crude protein				Ether extract			
1	Barley (alone)...	57.4	60.4	51.6	53.0	64.9	27.2	24.1	28.2
2	Barley (alone)...	56.8	55.5	48.2	48.8	64.6	22.1	10.2	22.8
3	Barley and corn (1 to 1).....	67.1	70.1	66.5	63.9	80.6	76.2	72.7	66.2
4	Barley and corn (1 to 1).....	65.5	69.9	65.5	63.5	65.3	72.1	59.5	49.8
5	Ground corn (alone).....	74.6	74.8	73.0	72.9	78.3	72.3	58.4	60.3
6	Ground corn (alone).....	77.5	72.8	73.2	73.2	64.9	75.6	52.0	57.2
7	Tankage and corn (1 to 7.5).....	76.2	72.5	75.4	74.4	73.5	76.2	79.3	69.2
8	Tankage and corn (1 to 7.5).....	76.1	74.2	72.4	73.0	82.0	84.0	71.2	70.7
	Average.....	68.9	68.8	65.7	65.3	71.8	63.2	53.4	53.1
		Dry substance				Nitrogen-free extract			
1	Barley (alone)...	73.5	71.9	71.3	69.8	81.9	81.1	82.9	80.4
2	Barley (alone)...	74.2	70.0	67.6	67.7	84.8	80.3	78.7	79.1
3	Barley and corn (1 to 1).....	82.1	80.8	81.0	81.0	88.9	88.4	89.6	89.5
4	Barley and corn (1 to 1).....	82.1	80.5	79.6	80.0	89.5	88.2	88.4	88.1
5	Ground corn (alone).....	87.2	86.4	85.2	85.7	91.9	91.2	91.0	91.2
6	Ground corn (alone).....	86.2	87.7	85.3	85.4	91.6	92.0	91.3	91.6
7	Tankage and corn (1 to 7.5).....	84.1	87.2	85.2	85.2	91.3	93.1	91.2	91.7
8	Tankage and corn (1 to 7.5).....	86.5	87.1	83.6	83.0	93.5	93.0	90.4	89.9
	Average.....	81.9	81.5	79.9	79.5	89.2	88.4	87.9	87.7

The results of this second series of experiments show greater differences in the coefficients of digestibility of the nutrients of the same feeds by different animals than did those of the first series. For example, the average coefficient of digestibility of the protein in the eight tests for Pig 214 was 5.5 percent greater than that for Pig 414. Again, the average coefficient of digestibility of the ether extract in the eight tests for Pig 114 was 35.2 percent greater than that for Pig 414. The total gain in live weight of Pig 114 for the 80 days was 26.3 percent greater than that for Pig 414.

The results of this second series of experiments support those obtained in the first series of experiments in demonstrating that the coefficients of digestibility of the nutrients of a number of different rations show constantly higher values for some pigs than for others.

The total gains in weight of each of the four pigs used in this experiment during the eight experimental periods, each of ten days,

duration during which time each of the four animals received the same kind of feeds and approximately the same quantity of feeds per 100 pounds of live weight, were as follows: Pig 114, 62.5 pounds; Pig 214, 57.0 pounds; Pig 314, 54.5 pounds; and Pig 414, 49.5 pounds. The average live weights of the pigs during the eight experimental periods were as follows: Pig 114, 277.5 pounds; Pig 214, 229.8 pounds; Pig 314, 218.3 pounds; and Pig 414, 200.5 pounds. The weights of the total feeds consumed during this same time were as follows: Pig 114, 459.2 pounds; Pig 214, 376.8 pounds; Pig 314, 364.0 pounds; and Pig 414, 335.6 pounds. The weights of feed required to produce 100 pounds of gain during the ten experimental periods were as follows: Pig 114, 735 pounds; Pig 214, 661 pounds; Pig 314, 668 pounds; and Pig 414, 678 pounds.

Comparing these gains in live weight and the economy of gains in weight with the average coefficients of digestibility of the nutrients of the feeds for each animal, it will be observed that there is possibly a better correlation between the coefficients of digestibility and the gains or the economy of the gains in weight in this second series of experiments than there was in the first series. For example Pig 214, which on the average digested all of the nutrients of the feeds somewhat more thoroly than Pigs 314 and 414, altho weighing on an average 277.5 pounds, made a gain of 57 pounds and required only 661 pounds of feed to produce 100 pounds of gain; while Pigs 314 and 414, weighing only 218.3 and 200.5 pounds, respectively, made gains of 54.5 and 49.5 pounds, respectively, and required 668 and 678 pounds of feed, respectively, to produce 100 pounds of gain. These results would seem to indicate that Pig 214 possibly made more economical gains than Pigs 314 and 414. Further, Pig 314, which on the average digested all of the nutrients of the feeds only very slightly more thoroly than Pig 414, altho weighing somewhat more than that pig, yet possibly made slightly the more economical gains of the two. On the other hand, Pig 114, which on the average digested all of the nutrients of the feeds almost as thoroly as Pig 214, altho weighing 47.7 pounds more than Pig 214, gained 62.5 pounds but required 735 pounds of feed to produce 100 pounds of gain, while Pig 214 gained 57 pounds and required only 661 pounds of feed to produce 100 pounds of gain. However, the difference between these two pigs as to economy of gains may be due, in large part at least, to the difference in their live weights.

## SUMMARY OF DATA OF BOTH SERIES OF EXPERIMENTS

1. *Dry Substance*.—The order of the rations according to decreasing coefficients of digestibility of their dry substance was as follows: ground corn, 87.1; tankage and ground corn, 86.0; ground barley and ground corn, 80.9; wheat flour middlings and ground corn, 79.1; wheat flour middlings, 74.4; and ground barley, 70.8.

2. *Nitrogen-free Extract*.—The order of the rations according to decreasing coefficients of digestibility of their nitrogen-free extract was as follows: tankage and ground corn, 92.2; ground corn, 92.1; ground barley and ground corn, 88.9; wheat flour middlings and ground corn, 85.9; wheat flour middlings, 81.2; and ground barley, 81.2.

3. *Crude Fiber*.—The order of the rations according to decreasing coefficients of digestibility of their crude fiber was as follows: tankage and ground corn, 51.2; ground corn, 34.8; wheat flour middlings, 21.0; ground barley and ground corn, 15.0; ground barley, 14.1; and wheat flour middlings and ground corn, 12.1.

4. *Crude Protein*.—The order of the rations according to decreasing coefficients of digestibility of their crude protein was as follows: wheat flour middlings, 80.0; wheat flour middlings and ground corn, 77.3; tankage and ground corn, 74.8; ground corn, 74.5; ground barley and ground corn, 66.5; and ground barley, 54.0.

5. *Ether Extract*.—The order of the rations according to decreasing coefficients of digestibility of the ether extract was as follows: wheat flour middlings, 85.4; wheat flour middlings and ground corn, 83.4; tankage and ground corn, 80.8; ground corn, 68.3; ground barley and ground corn, 67.8; and ground barley, 33.0.

6. *Average Coefficients of Digestibility of the Rations*.—The following is a summary of the average coefficients of the rations fed in these experiments:

Ration	No. of ex- peri- ments	Dry sub- stance	Nitro- gen- free ex- tract	Crude fiber	Crude pro- tein	Ether ex- tract
Wheat flour middlings .....	16	74.4	81.2	21.0	80.0	85.4
Ground corn .....	16	87.1	92.1	34.8	74.5	68.3
Ground barley .....	8	70.8	81.2	14.1	54.0	33.0
Wheat flour middlings and ground corn (1 to 1) .....	8	79.1	85.9	12.1	77.3	83.4
Ground barley and ground corn (1 to 1) .....	8	80.9	88.9	15.0	66.5	67.8
Tankage and ground corn (1 to 7.5) .....	16	86.0	92.2	51.2	74.8	80.8

7. *Influence of One Feed upon the Digestibility of the Nutrients of Another Feed.*—The following is a summary of the average results which show the influence of one feed upon the digestibility of another feed:

Ration	No. of ex- peri- ments	Dry sub- stance	Nitro- gen- free ex- tract	Crude fiber	Crude pro- tein	Ether ex- tract
Middlings—direct . . . . .	8	74.7	82.2	22.8	79.3	82.3
Middlings—indirect . . . . .	8	70.7	77.2	6.1	78.3	89.3
Corn—direct . . . . .	8	87.8	92.7	30.8	75.1	71.7
Corn—indirect . . . . .	8	83.7	88.9	-2.2	73.0	81.3
Barley—direct . . . . .	8	70.8	81.2	14.1	54.0	33.0
Barley—indirect . . . . .	8	76.1	86.2	3.7	60.2	68.9
Corn—direct . . . . .	8	86.2	91.5	38.8	74.0	64.9
Corn—indirect . . . . .	8	91.8	96.6	15.6	81.4	68.7
Middlings and corn—direct . . . . .	8	79.1	86.0	12.1	77.3	83.5
Middlings and corn—indirect <sup>1</sup> . . . . .	8	81.1	88.1	24.8	78.0	78.8
Middlings and corn—indirect <sup>2</sup> . . . . .	8	77.1	83.8	-0.7	76.6	88.1
Barley and corn—direct . . . . .	8	80.9	88.9	15.0	66.5	67.8
Barley and corn—indirect <sup>1</sup> . . . . .	8	78.3	86.3	20.4	63.2	54.0
Barley and corn—indirect <sup>2</sup> . . . . .	8	83.7	91.3	6.6	69.9	80.7

<sup>1</sup>Calculated from the direct determinations of the coefficients of the individual feeds.

<sup>2</sup>Calculated from the indirect determinations of the coefficients of the individual feeds.

8. *Individuality of Pigs as to the Thoroness With Which They Digest Their Feeds.*—Summaries of the nutrients of the feeds showing the individuality of pigs as to the thoroness with which they digest their feeds are given on pages 72 and 87 of this bulletin.

## CONCLUSIONS

1. The weights of the feces of pigs, per pound of feed, vary markedly depending upon the character of the ration. Such differences in the weights of the feces per pound of feed are due, in large part at least, to variations in the water content of the feces and to variations in the coefficients of digestibility of the dry substance of the rations.

2. The results obtained in these experiments clearly indicate that in some cases one feed does not influence the digestibility of the individual nutrients of another feed with which it is fed, and in other cases that it does influence the digestibility of the individual nutrients of the other feed in one of the two following ways: first, the nutrients of the feeds when fed as mixed feeds are more digestible than they are when each feed is used alone; or, second, the nutrients of the feeds when fed as mixed feeds are less digestible than they are when each feed is used alone. With the limited data at present available relating

to this subject, it is impossible to explain logically these differences shown by different combinations of feeds, when fed together, upon the digestibility of their combined nutrients as compared with the digestibility of the nutrients of the individual feeds when fed alone.

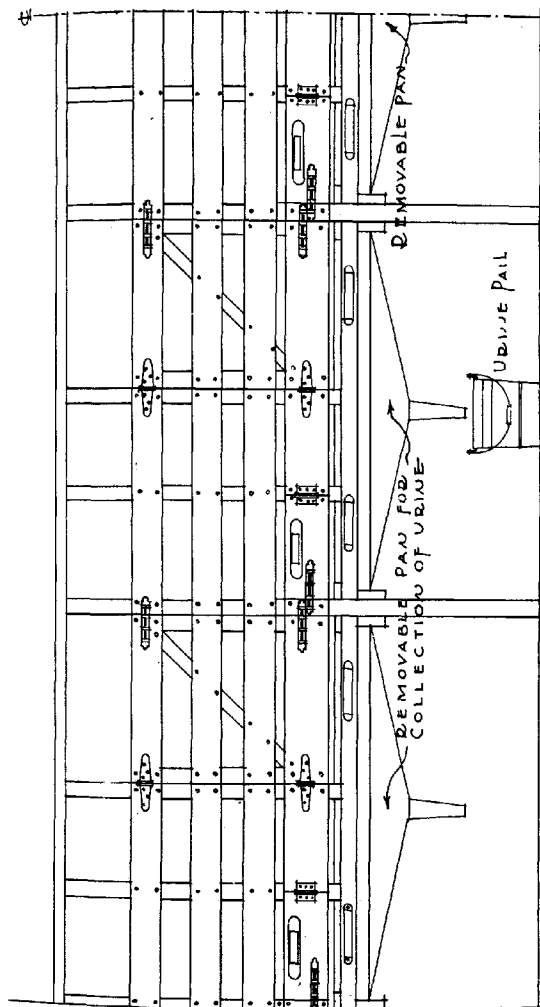
3. The results of these researches on the influence of one feed upon the digestibility of another feed demonstrate clearly: first, that the coefficients of digestibility of the nutrients of feeds calculated indirectly by subtracting the weights of the digestible nutrients of one feed as directly determined in other tests from the corresponding values for the two feeds combined, may be, and probably often are, decidedly inaccurate; and second, that the weights of the digestible nutrients of a mixed ration, calculated by the use of the coefficients of digestibility of the nutrients obtained directly for the individual feeds when fed alone, may be decidedly inaccurate.

4. It therefore apparently follows that in order to obtain strictly accurate results for the coefficients of digestibility of mixed rations, digestion experiments should be made directly upon the mixed rations as fed. In other words, in the future coefficients of apparent digestibility of the nutrients for *mixed* rations should be obtained and reported, rather than those for *individual* feeds composing the rations.

5. The results of these experiments demonstrate clearly that different animals of the same species may show individuality as to the thoroughness with which they digest the nutrients of their feeds. In other words, under conditions that are practically identical thruout the same experiment, the coefficients of digestibility of the nutrients of a number of different rations show significantly higher values for some pigs than for others. However, the differences in the coefficients of digestibility of the nutrients of the same feeds by the different pigs are probably too small to be considered of much, if any, practical or economic importance.

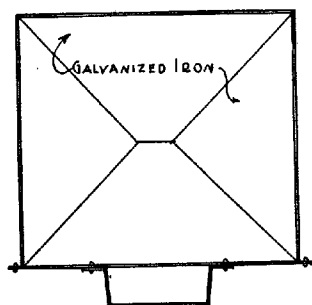
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The authors wish to acknowledge the efficient assistance rendered by W. F. Campbell in the feeding, weighing, and care of the animals.

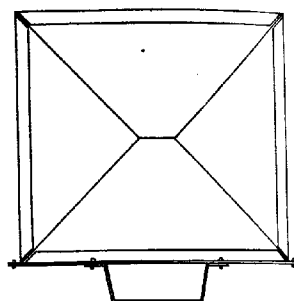


FRONT VIEW  
FIG. 1 - DIGESTION STALLS FOR SWINE

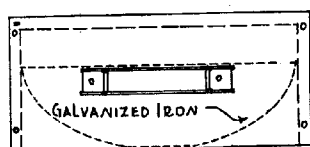




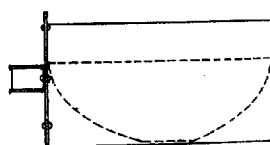
TOP VIEW



BOTTOM VIEW



FRONT VIEW



SIDE VIEW

NOTE:-  
THE DOTTED LINES SHOW THE CURVATURE OF THE FALSE BOTTOM.

FIG. 2—FEED TROUGH

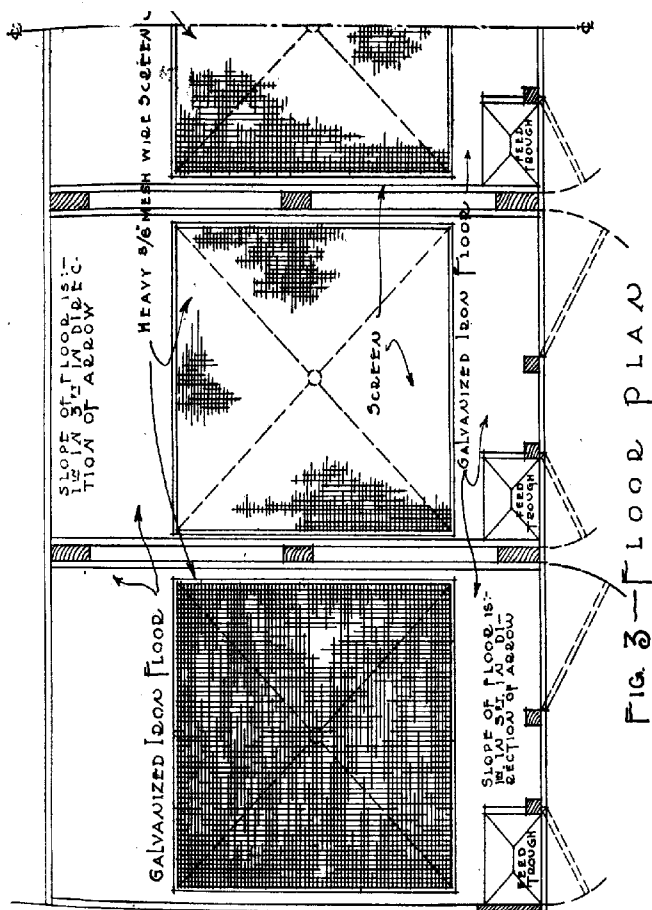




FIG. 4.—DIGESTION HARNESS

